1st Beam of an Ultra-high Gradient Traveling Wave Photogun

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on behalf of joint efforts from Euclid Techlabs, AWA, and NIU

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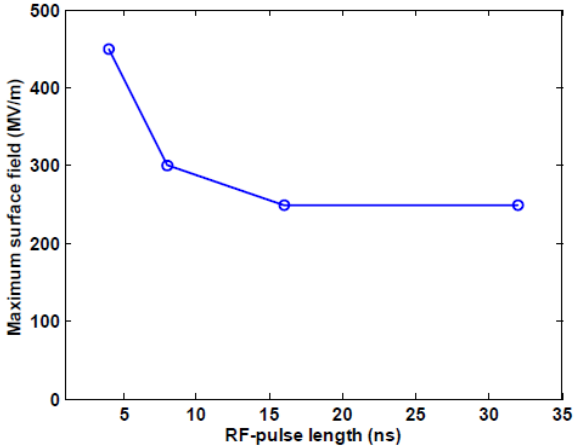
Motivation

- Empirical formula summarized from decade of high gradient accelerator research

$$BDR \propto E^{30} \tau^{5}$$

A. Grudiev *et al.*, *Phys. Rev. ST-AB*, 12, 102001 (2009).

- Early time study in CLIC, 30GHz era



W. Wuensch et al., Proc. PAC03, 495–497, 2003.

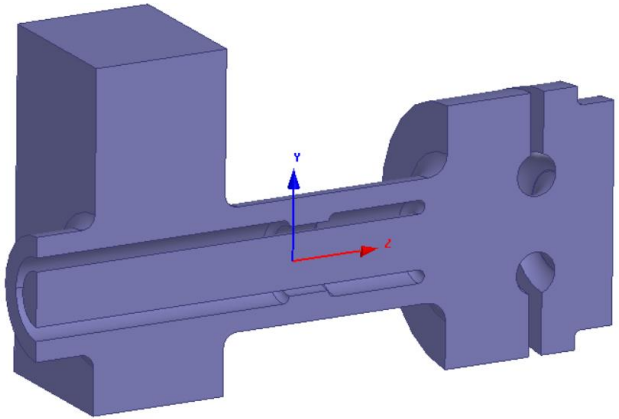
LCLS photogun, the most successful Cu photogun: S-Band, 3~4 us rf pulse, 120MV/m on Cathode

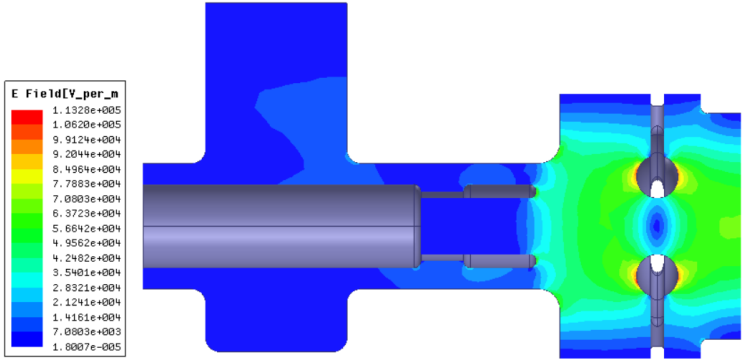
?

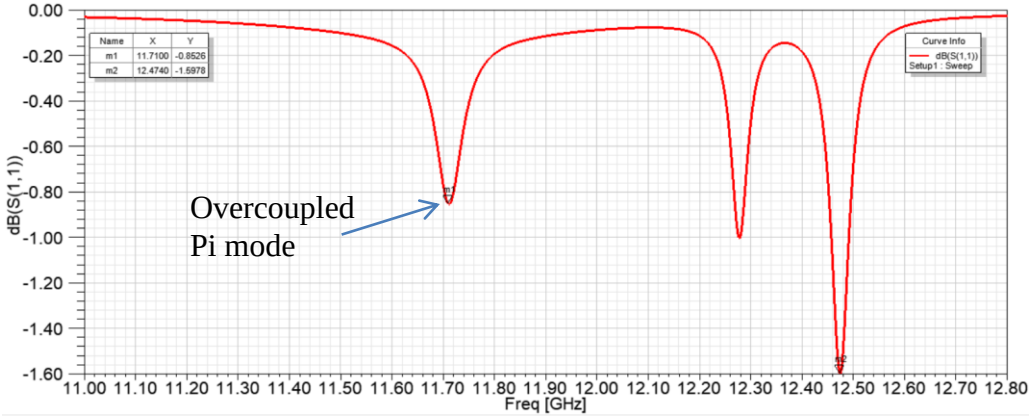
<10ns rf pulse, >300MV/m on Cathode→lower ε_{sc}

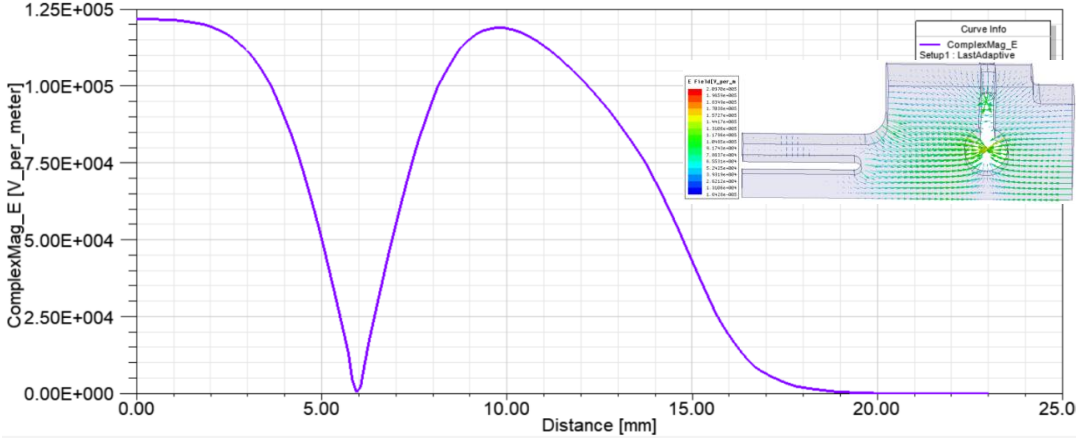
1.More efficient for no beamloading applications
2.Less dark current

Design---RF properties





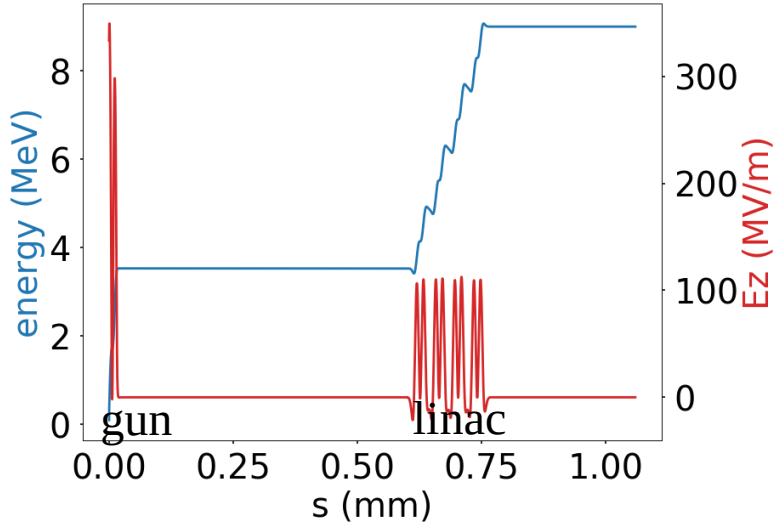


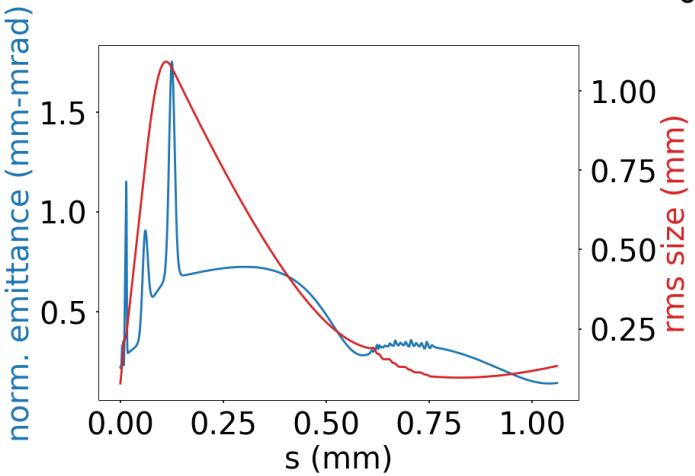


Design---beam simulation

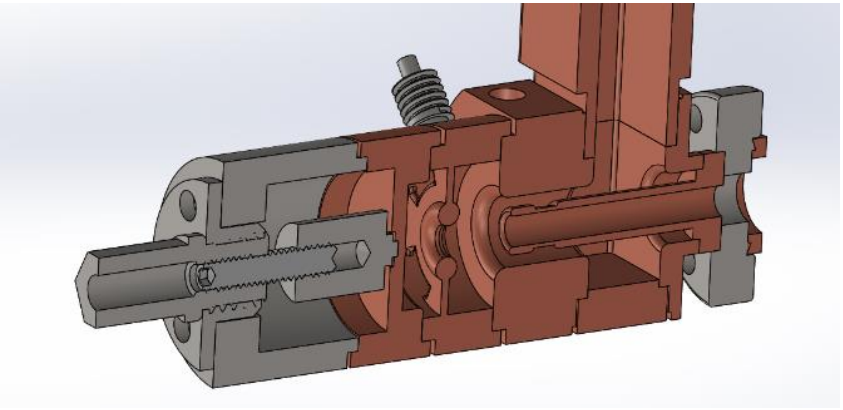
Parameter	Value
Laser spot size on cathode	70 micron
Flat top laser rms length	3.2 ps
Peak field on cathode	350 MV/m
Charge	100 pC
Normalized emittance	0.15 mm-mrad*
RMS bunch length at exit	365 micron
Relative energy spread at exit	0.003
Beam energy at gun exit	3.1 MeV
Beam energy at exit	8.5 MeV

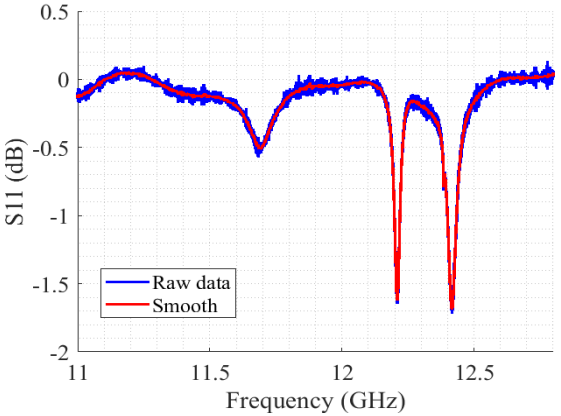
* Optimized with existing components in hand (solenoid, linac, etc).

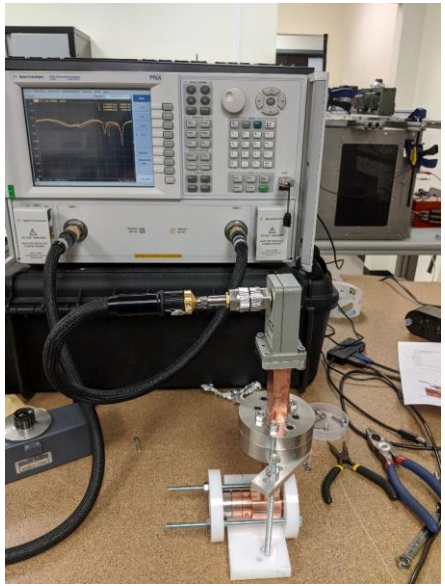


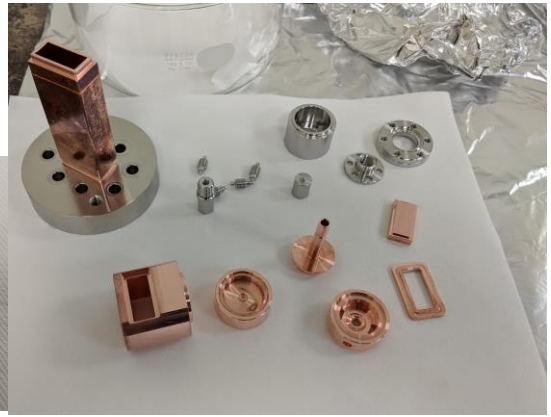


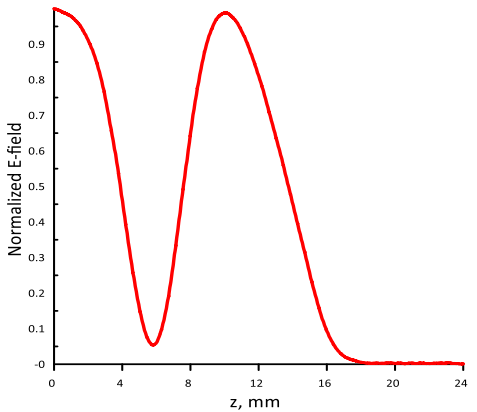
Engineering, Fabrication, and Bench Test





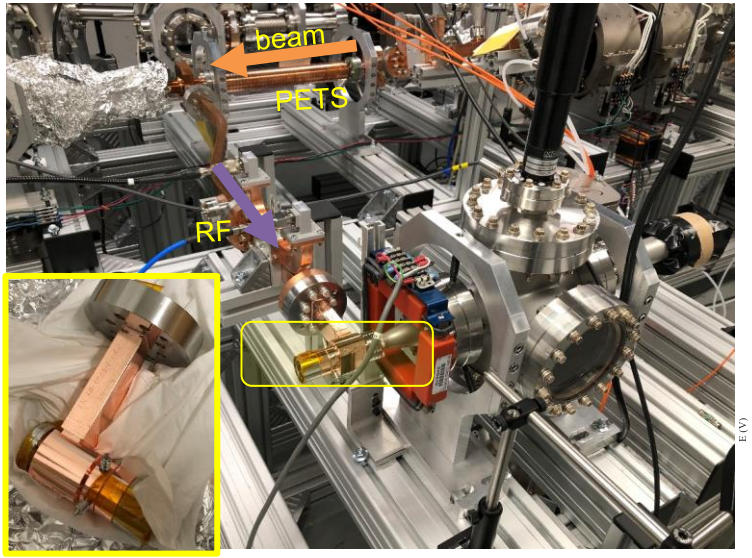


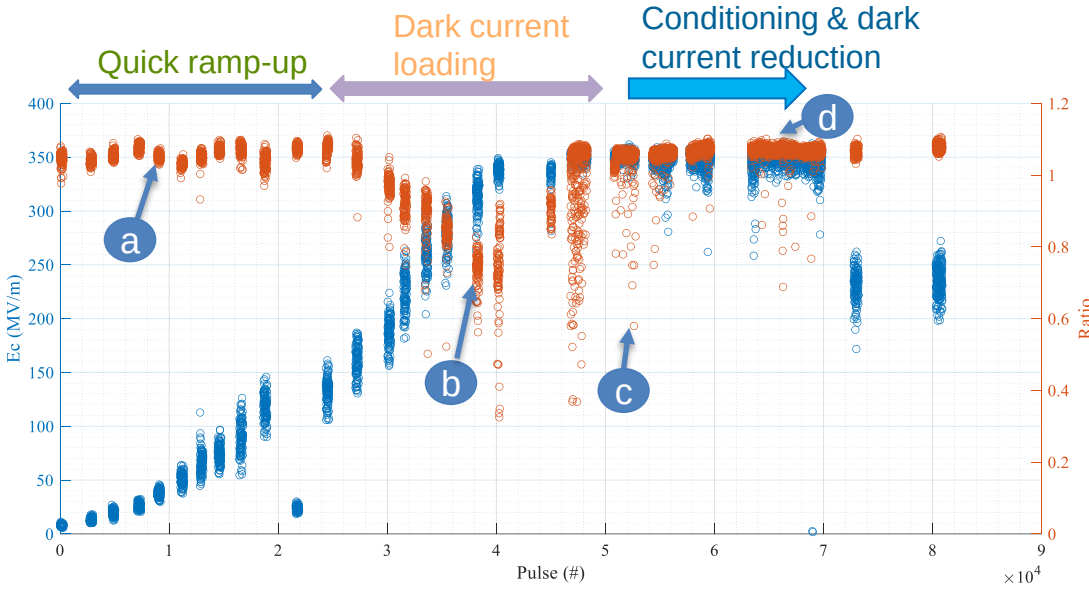


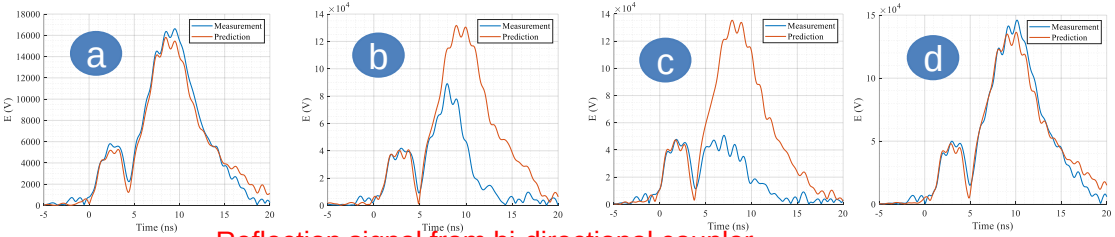


Conditioning

- Achieved 350MV/m on cathode
- Observed strong dark current loading regime but quickly conditioned away
- It only took 70k pulses for a full condition
- Back to 200MV/m to 250MV/m region, no breakdown, no measurable dark current

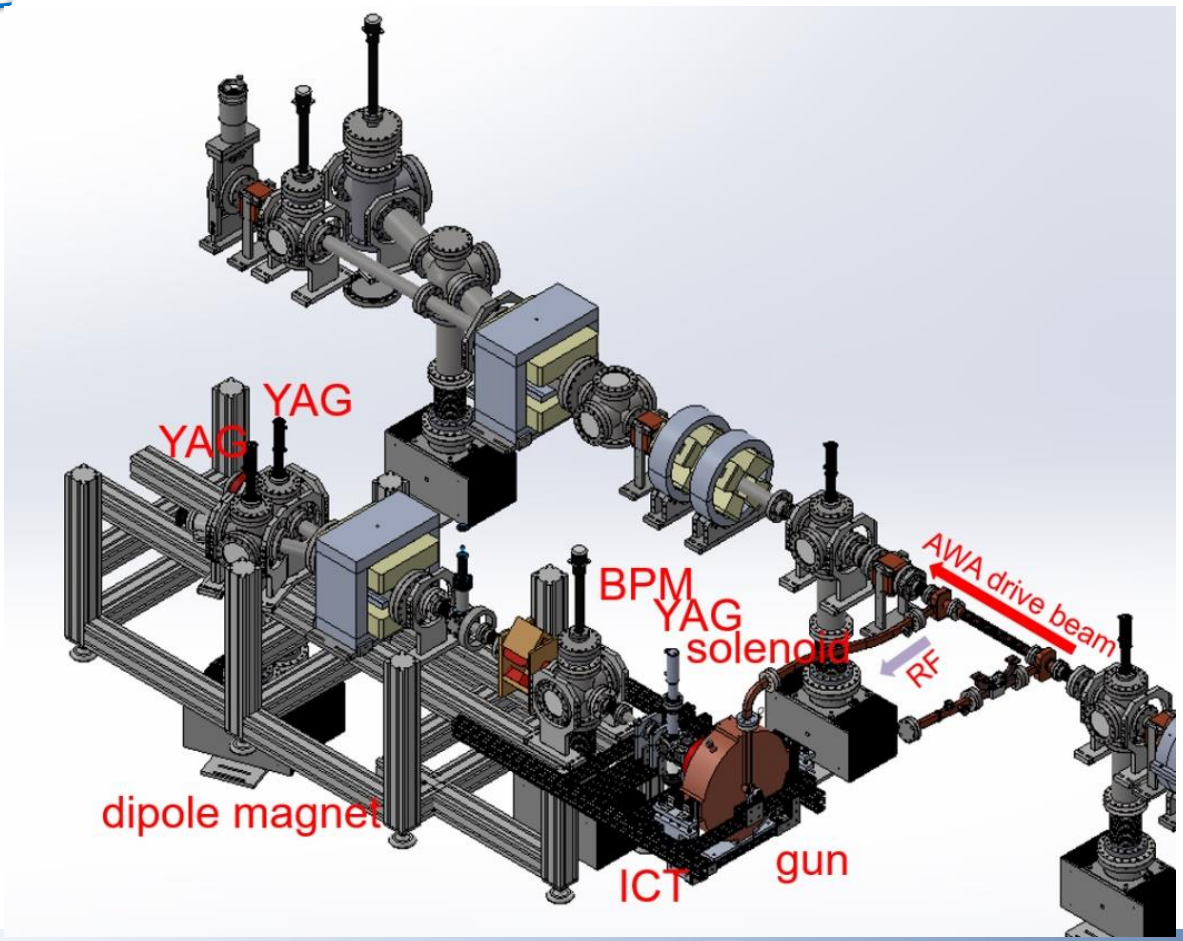






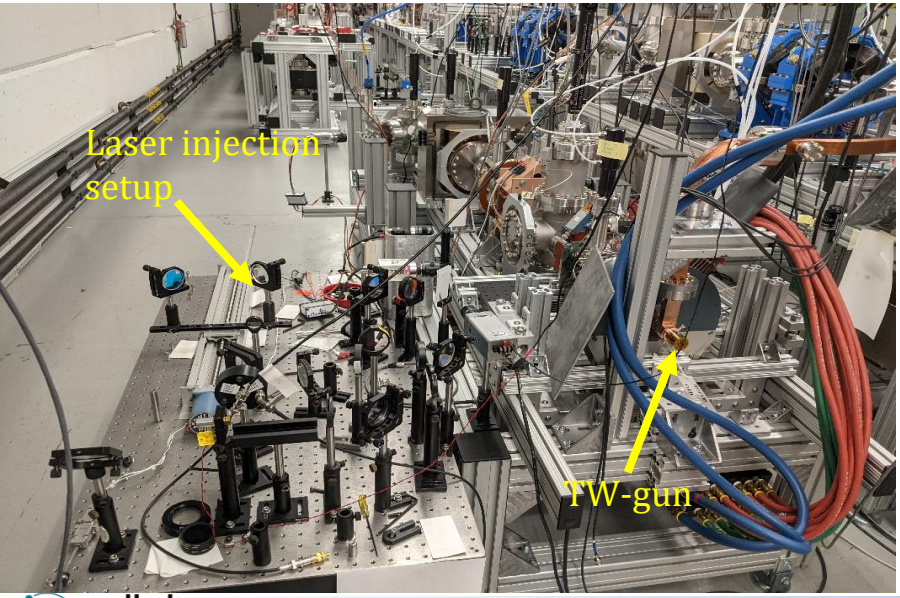
Reflection signal from bi-directional coupler

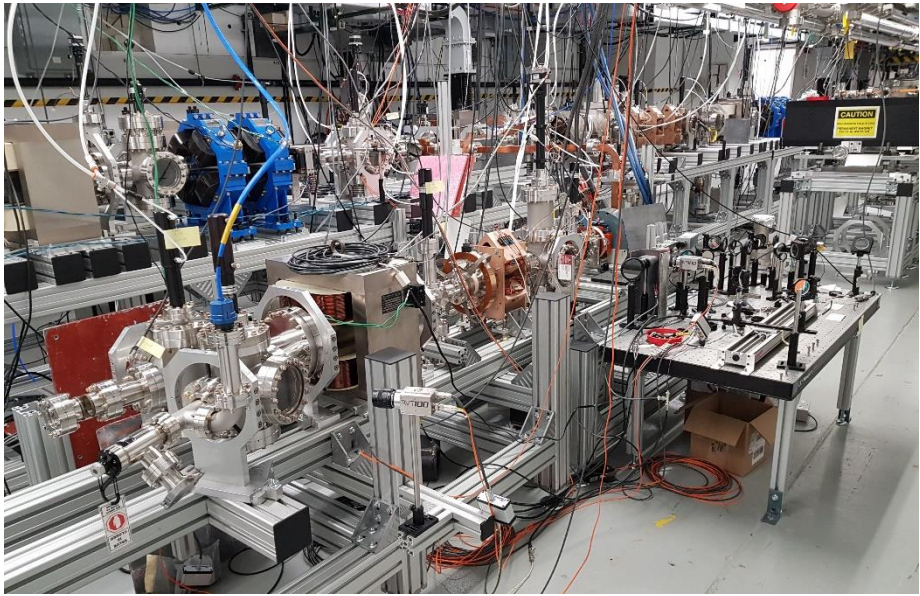
Beamline


YAG
YAG
BPM
YAG
solenoid
AWA drive beam
RF
dipole magnet
ICT
gun

Beamline---beam generation

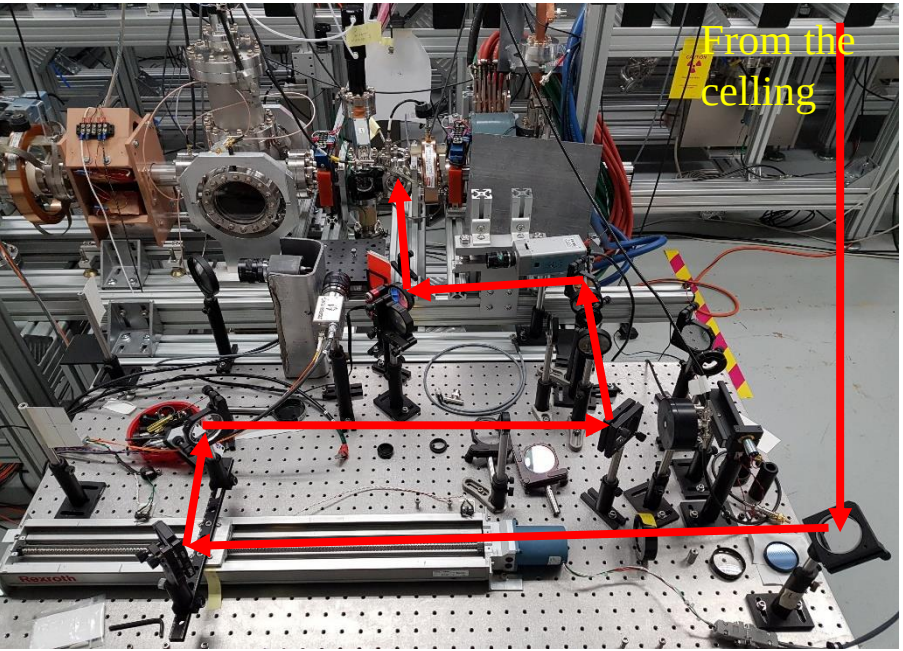
- First beamline was constructed without Linac.
- The goal is to generate the beam, measure the charge and the energy

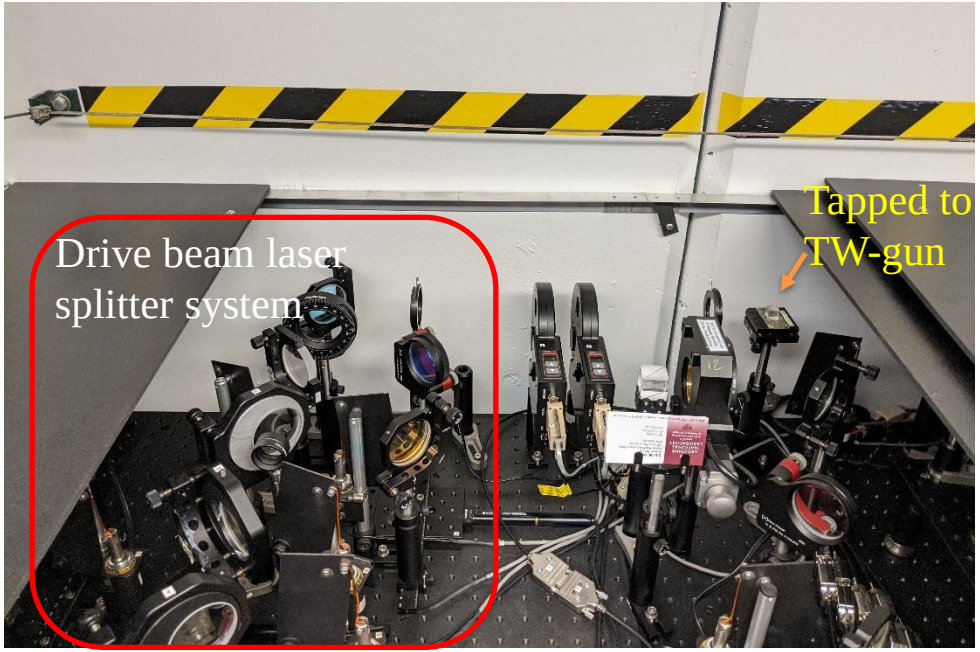




Beamline---laser transportation

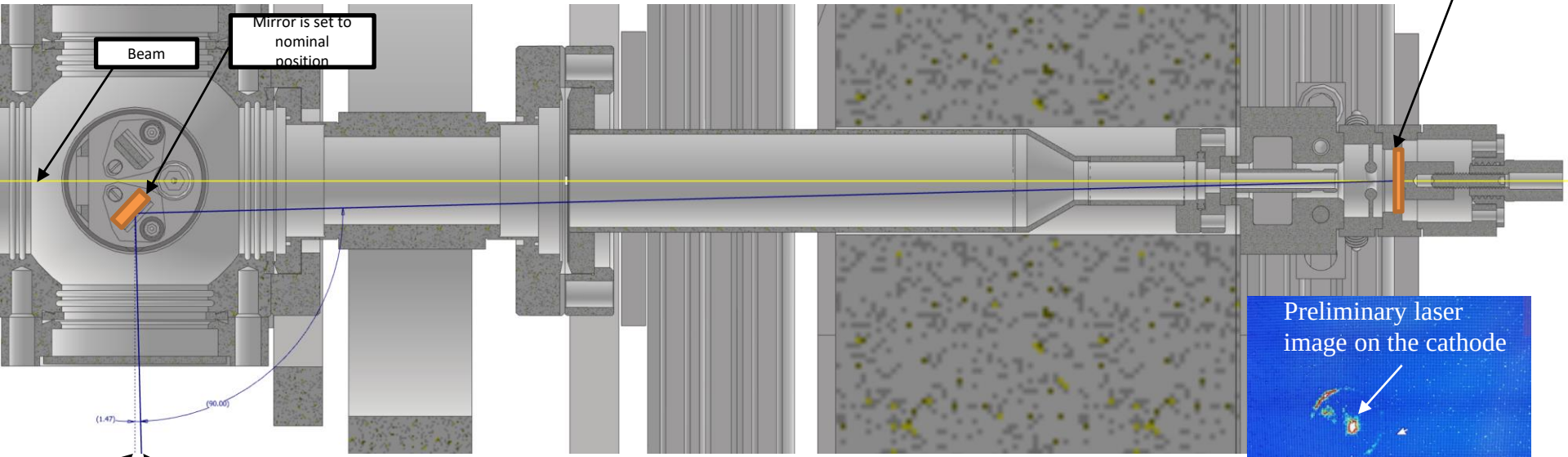
- Challenge to get the timing correct between the laser to the drive photogun and TW-photogun.





Beamline---laser alignment

- Challenging alignment to the TW-photogun cathode



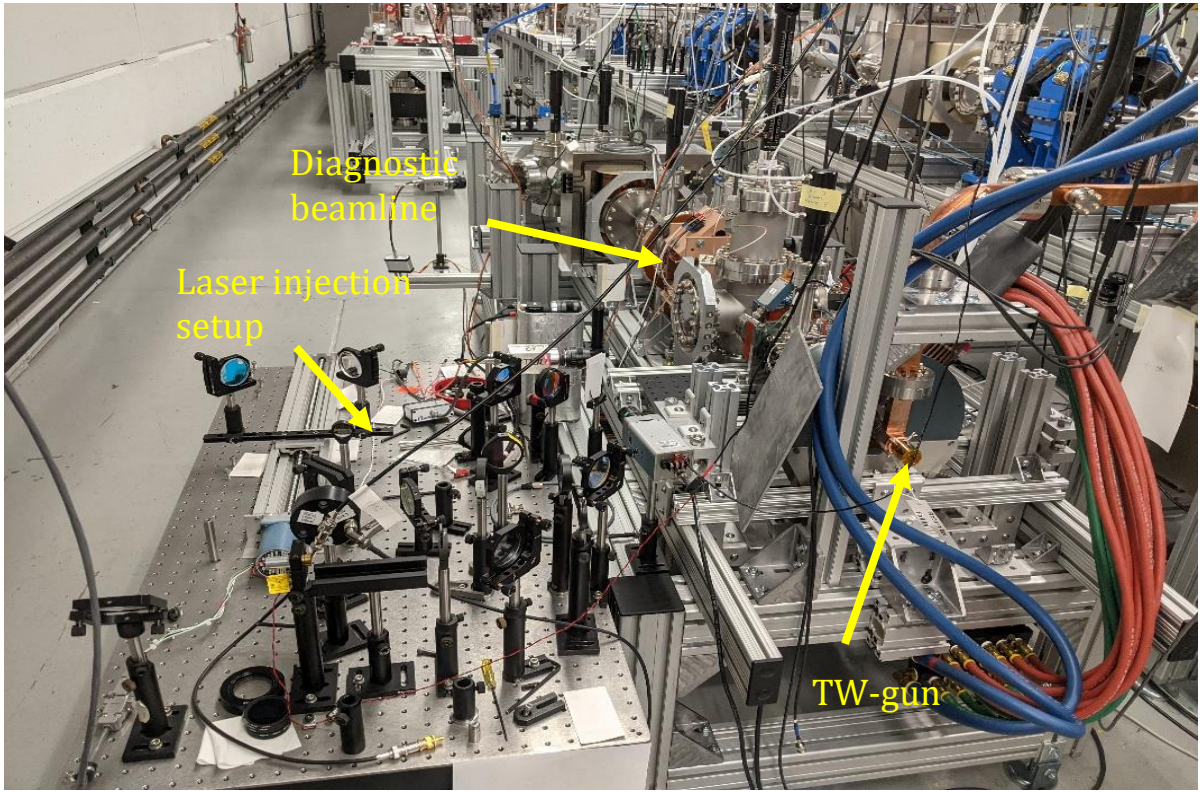
Preliminary laser image on the cathode

Dotted line is perpendicular to beam.

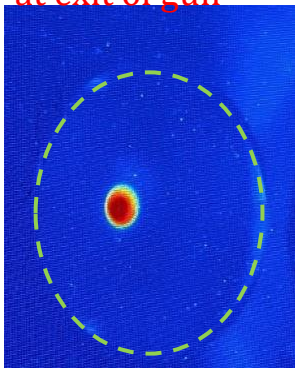
Laser IN shown at 90°.

In order to reach the cathode, you need a ~2° input angle. There is some adjustment in the mirror, but we had to close the vacuum, so, it is not accessible.

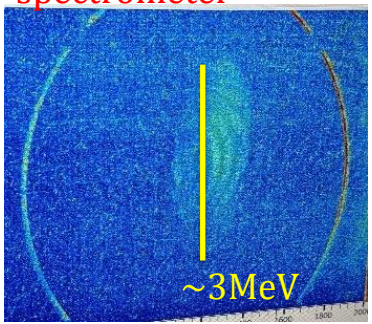
Experiment---1st Beam



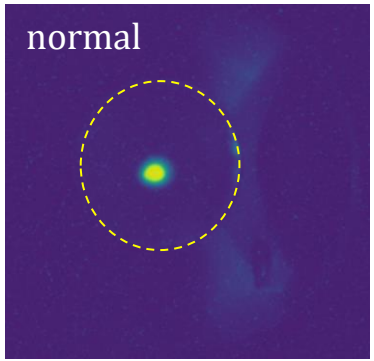
Beam on 1” YAG at exit of gun

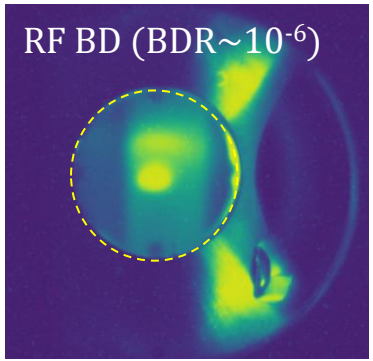


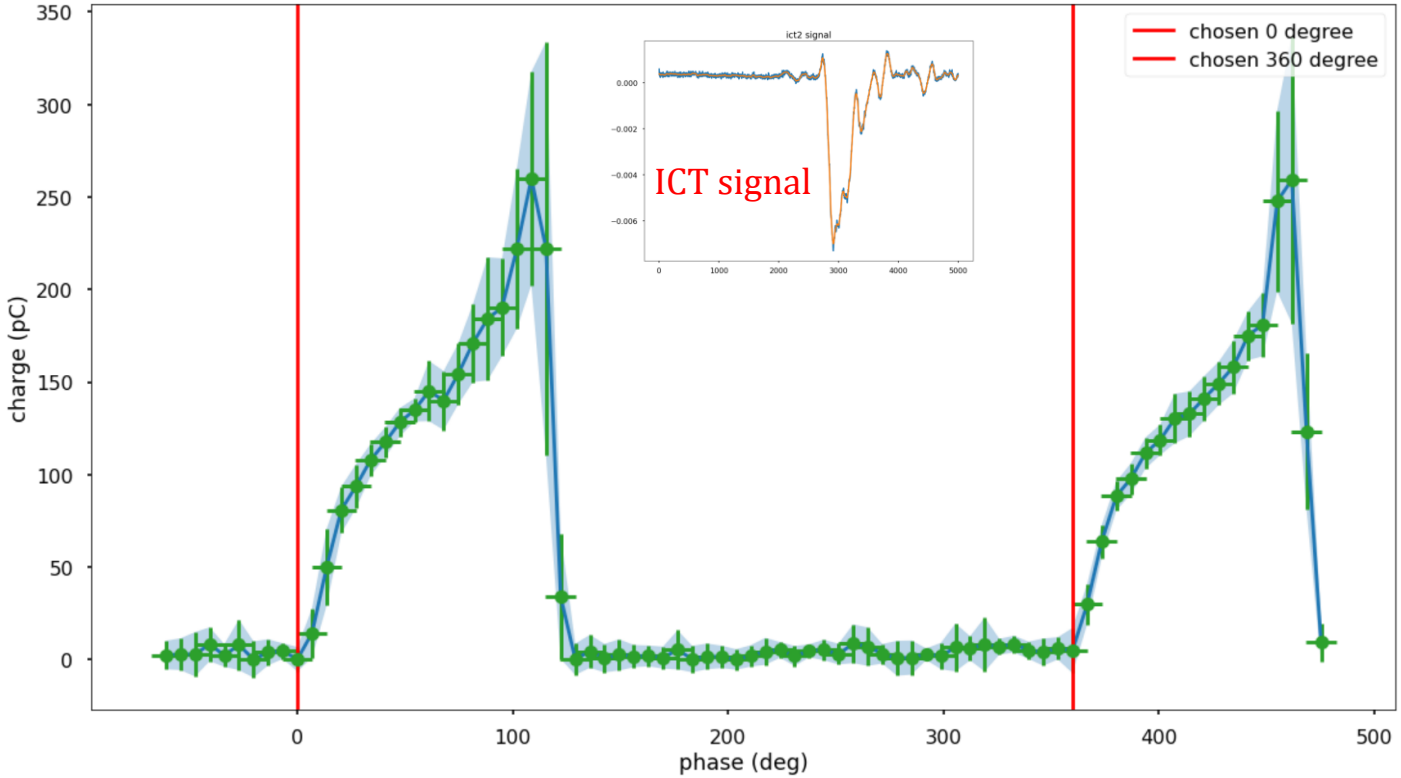
Beam on the energy spectrometer



Experiment---phase scan

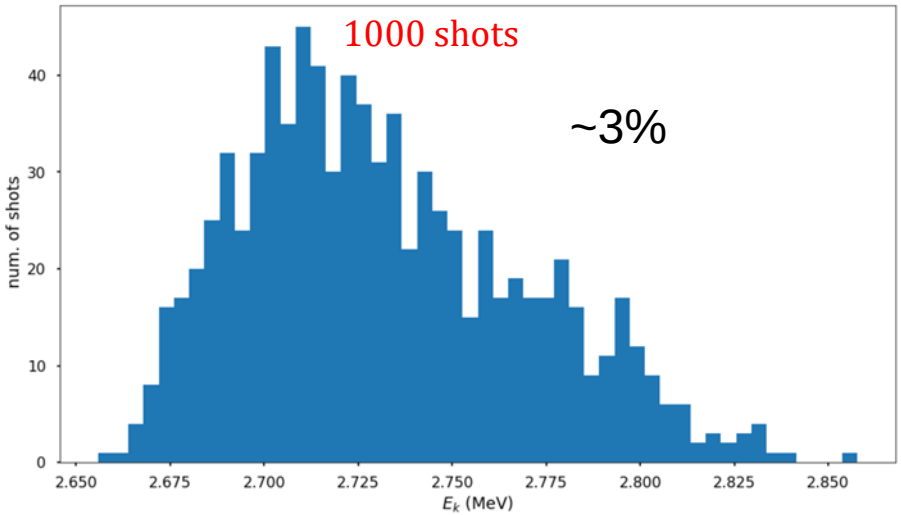


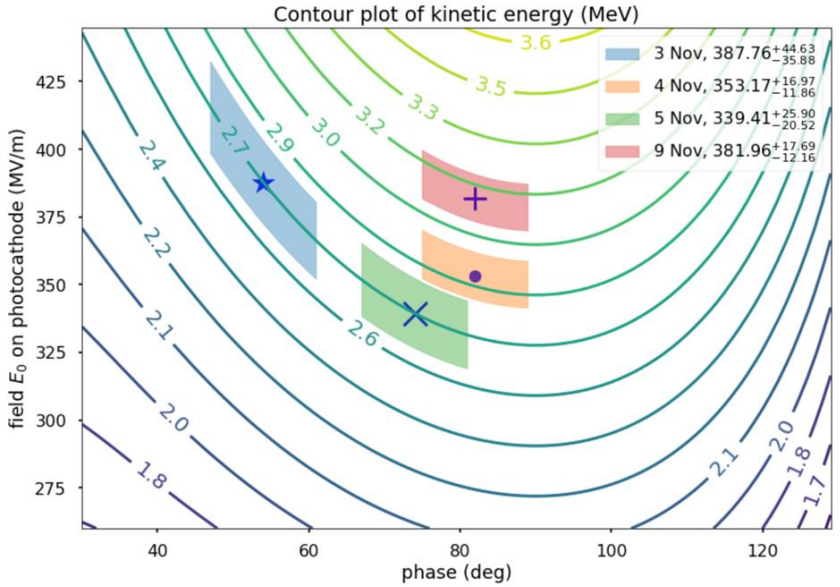




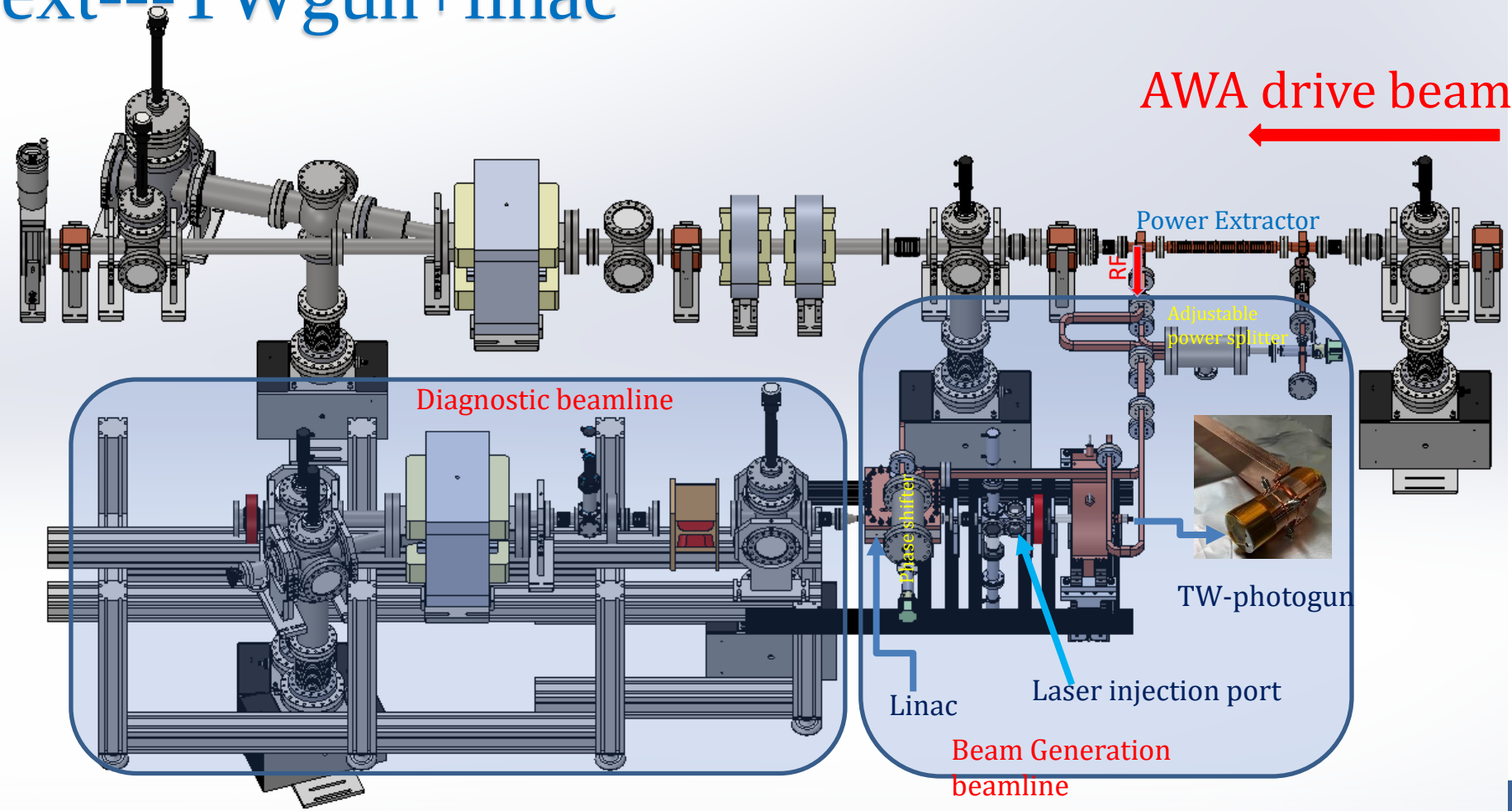
Experiment---energy jitter

- More detailed work is needed to identify the jitter sources: rf phases, amplitude, laser timing, etc



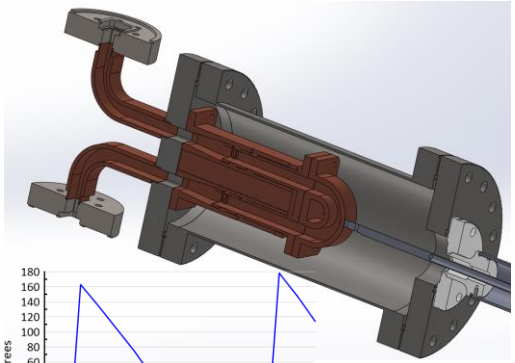


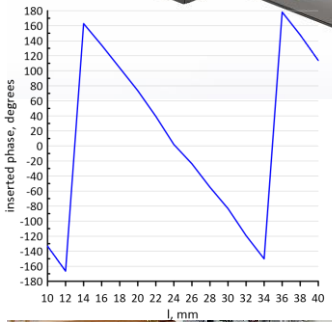
Next---TWgun+linac

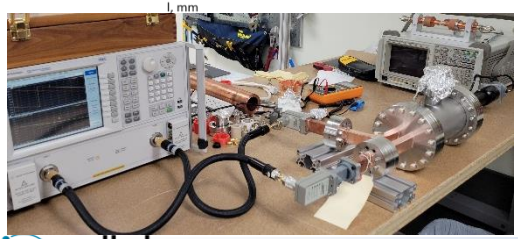


Next---components

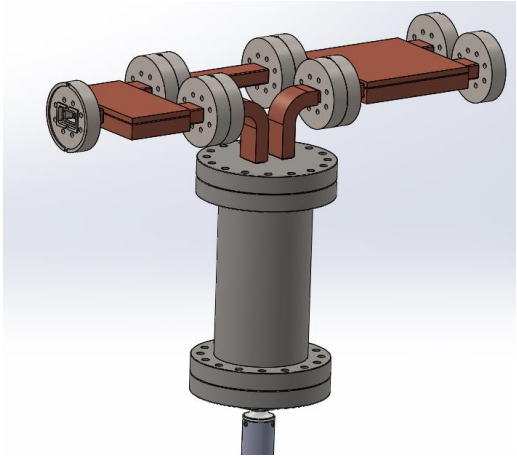
Phase shifter

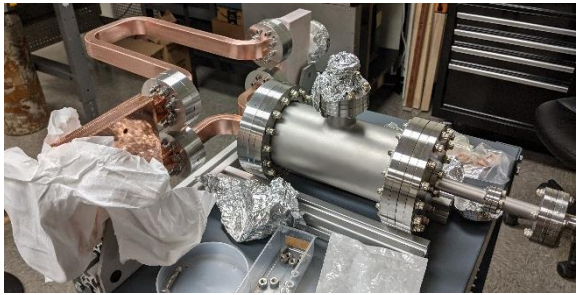




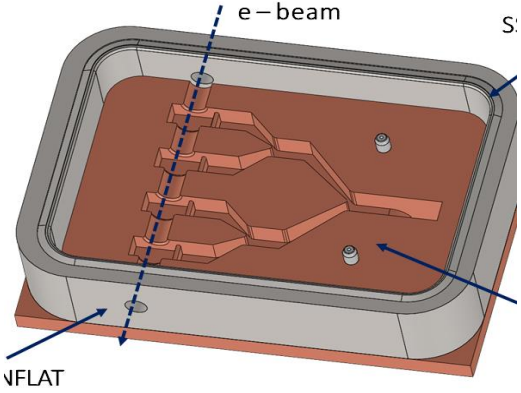


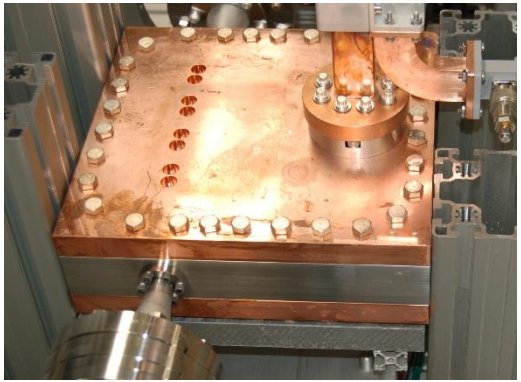
Adjustable power splitter



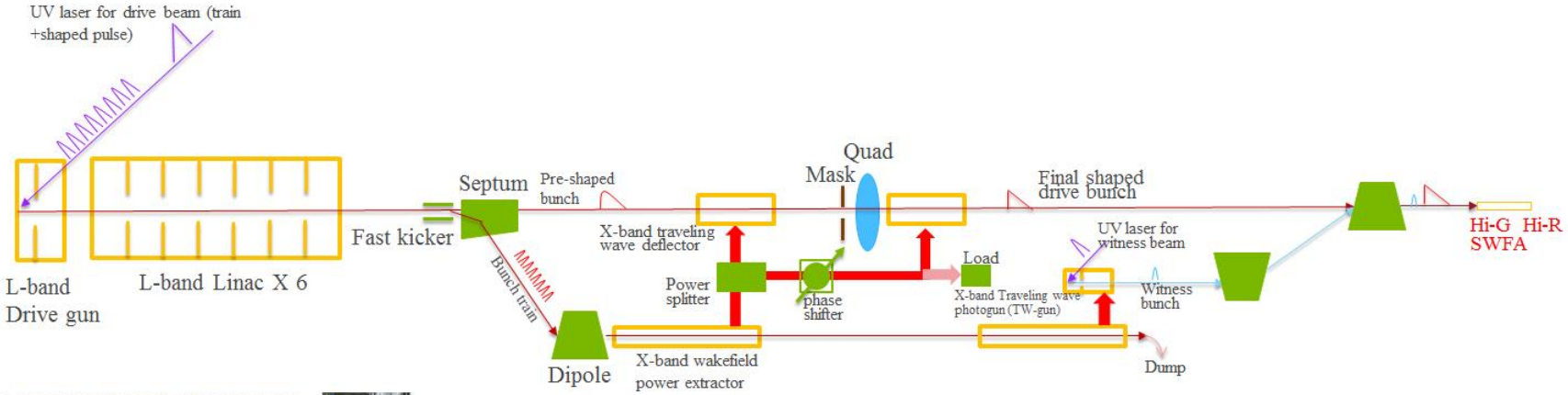


Brazeless linac





Next---Application



Fast kicker has been tested

Septum has been built

Power splitter (under fabrication)

phase shifter (under fabrication)

Power Extractors and Traveling wave gun have been tested

Note: 1. only key elements are enclosed in this simplified configuration.
2. Main diagnostics will be needed, e.g. YAG, BPM, energy spectrometer, deflector for longitudinal phase space measurement, etc.
3. This proposed experiment has strong synergies with our collaborator Prof. Philippe Piot NIU as well as the AWA facility.

Summary

- Take advantage of the Short RF pulse to reach ultrahigh gradient in a photogun, thus a high quality beam.
- Deliverable is to establish an X-band photoemission beam source at AWA for SWFA study.

Acknowledgment

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AWA Team: John Power, Eric Wisniewski, Wanming Liu, Jiahang Shao, Gwanghui Ha, Scott Doran, Charles Whiteford, Seongyeol Kim.

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